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Notes on identity, new synonymy and larva of *Ivalia* Jacoby (Coleoptera: Chrysomelidae) with description of a new species

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Abstract

Genus *Ivalia* Jacoby is characterized morphologically, and *Amphimeloides* Jacoby **syn. nov.** and *Taizonia* Chen **syn. nov**. are junior synonyms with it. Several *Ivalia* species are figured, including *Ivalia bella* (Chen) **comb. nov.**, *I. dorsalis* (Jacoby) **comb. nov.**, and *I. viridipennis* Jacoby. A new species of *Ivalia* from the Nilgiri Hills in south India, *I. korakundah* **sp. nov.**, is described and illustrated, including the larvae. Larvae were associated with adults by sequencing a fragment of the mitochondrial gene cytochrome oxidase I. Larval morphology is discussed and compared with that of other flea beetles.

Key words: Chrysomelidae, *Ivalia, Taizonia, Amphimeloides*, moss feeding, larval sensilla, new species

Introduction

Jacoby (1887:100) proposed *Ivalia* to accommodate “small species of Halticinae having general shape and appearance of *Apteropeda*, but differing from that … by the irregularly punctured elytra and the appendiculate claws”. A few pages earlier in the same paper Jacoby described another genus, *Amphimeloides*. Unfortunately and inexplicably, he did not compare the two, although both are described from Sri Lanka and share some important characters including small size with a similarly round and convex body, open procoxal cavities, irregularly punctured elytra, appendiculate claws, and a long metatibial

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spur. Instead *Ivalia* was compared with *Apteropeda*, a European genus with a relatively small range, while *Amphimeloides* was compared with *Amphimela*, an Asian genus, obviously different from the taxon under consideration in various features.

Taizonia was described some years later (Chen 1934) and it is unclear how much comparative data was used to establish that genus. The most complete up-to-date treatment of *Taizonia* was published by Gruev and Askevold (1988), who synonymized Medvedev's *Schereria*, transferring *Chabria minima* Scherer (the type species of *Schereria*) and *Schereria martensi* Medvedev to *Taizonia*. Gruev and Askevold (1988) also described two new species of *Taizonia* from India and provided a key to all ten *Taizonia* species known to date. Similarity between *Taizonia* and *Ivalia* was first noted by Medvedev (2001). After studying *Ivalia metallica* Jacoby and *I. ruficollis* (Motschulsky), he commented that they were similar to Taiwanese *Taizonia* in their "saddle-like" metasternum, long first metatarsomere and dorsal surface of metatibia varying from grooved to flattened sometimes with ridges. He noticed that Indian *Taizonia* has a slightly shorter first metatarsomere. However, he did not propose any synonymy.

In this study we aim to increase morphological understanding of *Ivalia*, propose new synonyms, describe a new species from south India, and describe the larva of *Ivalia*.

Materials and methods

Traditional techniques were used to dissect specimens and prepare them for scanning electron microscopy. For adults, scanning electron microscopy was performed on uncoated material at 10Kv.

Male abdomen and pterothorax were cleared using DNA extraction enzymes (Qiagen™ 'DNAeasy tissue kit') prior to mounting (Figs 3C-G). Larvae were critical point dried and coated with gold palladium and also imaged at 10Kv. DNA was extracted, amplified, and purified using Qiagen™ extraction, PCR, and purification kits. The PCR protocol included 40 cycles, the first 10 cycles with an annealing temperature of 46° and the subsequent 30 at 48°C. Otherwise the PCR protocol was standard. DNA was prepared for sequencing in an ABI 3100 plate sequencer using ABI Big dye 3.1chemistry.

Identity of the larval beetles was established by sequencing a fragment of the COI locus using primers modified from Simon *et al.* (1994) designed to amplify base pairs between nucleotides 1709–2355, 1718–2329 and 1751–2203.

Forward primers are:
COI 1709F 5'TAATTGGAGGATTTGGWAAYTG—3',
COI 1718F 5'GGAGGATTTGGAAATTGATTAGTTCC—3'.
COI 1751F 5—GGA TCA CCT GAT ATA GCA TTC CC—3'.
Reverse primers are:
COI—2191R 5'—CCYGGTAAAATTAAAATATAAACTTC—3',
COI 2203R 5'—AATTARAATATAWACTTCWGRTG—3',

COI 2329R 5'—ACTGTAAATATATGATGAGCTCA—3',
COI 2355R 5'—GCTCGTGTATCWACGTCTAT—3'.

Two adults and two larvae were sequenced twice using two different primer pairs; *Ivalia* sp. 1 from Ponmudi, Kerala was also sequenced twice for comparison. We obtained a 547 bp piece from amplicons resulting from the use of these pairs, which we considered reliably sequenced. This consensus sequence for each individual was aligned using Clustal W (Thompson *et al.* 1994) to the sequences of the other individuals. This alignment was tested for accuracy by translation to amino acids using the MacClade (Maddison & Maddison 2001) program. *Ivalia korakundah* sequences are deposited in Genbank under accession numbers DQ080034–DQ080037 and *Ivalia* sp. 1 under accession DQ080038. Voucher material from extracted specimens is deposited at USNM.

Descriptive terminology of the adults follows Konstantinov (1998) and that of larvae follows Duckett and Casari (2002), Duckett and Swigonova (2002) and LeSage and Zmudzinska-Krzesinska (2004). The following institution abbreviations are used in this paper: BMNH — The Natural History Museum, London, United Kingdom; DEIM — Deutsches Entomologisches Institut, Müncheberg, Germany; NHMB — Natural History Museum, Basel, Switzerland; PKDC — K. D. Prathapan personal collection, Trivandrum, India; SMFM — Senckenberg Museum Frankfurt/Main, Germany; USNM — National Museum of Natural History, Washington, DC, USA. CND is responsible for the molecular part of this project and for the larval description; the taxonomic part is the work of the junior authors.

Ivalia **Jacoby**
(Figs 1–8)

Ivalia Jacoby, 1887:100 (type species *Ivalia viridipennis* Jacoby 1887 designated by Maulik (1926), type locality Sri Lanka, type in BMNH).

Ancyloscelis Ogloblin, 1930:100–101 (type species *Mniophila ruficolle* Motschulsky 1866 by monotypy, type locality Sri Lanka, type probably lost). Scherer, 1969:234 (synonymy).

Amphimeloides Jacoby, 1887:95 (type species *Amphimeloides dorsalis* Jacoby 1887:96 by monotypy, type locality Sri Lanka, type in BMNH). **New synonym**.

Taizonia Chen, 1934:182 (type species *Taizonia bella* Chen 1934 by original designation, type locality Taiwan, type in DEIM). **New synonym**.

Schereria Medvedev, 1984:60 (type species *Chabria minima* Scherer 1984 by original designation, type locality Nepal, holotype in NHMB). Gruev & Askevold, 1988:140 (synonymy).

Notes on generic synonymy. Based on the study of various specimens, including type specimens of the type species, we conclude that *Taizonia* and *Amphimeloides* are junior synonyms of *Ivalia*. They share the following character extremely rare among flea beetles: metasternum is expanded anteriorly, becoming vertical and covering mesosternum (Fig. 5A) so the latter also becomes vertical and sometimes invisible in ventral view. This character is shared by the types of all the type species, but varies slightly among other

studied species of *Ivalia.* In its most developed state, the character is known to occur only in *Clavicornaltica* Scherer (Konstantinov & Duckett 2005), also a humicole feeder but easily distinguishable from *Ivalia* by its clavate antennae and other features.

Other uncommon characters occuring in *Ivalia* and some other Oriental genera include the following: a. Metatibia curved in dorsal view with long metatibial spur (Figs 1, 3E, F), first metatarsomere as long as or longer than two following tarsomeres combined (Figs 2D, 3F); b. Labrum deeply emarginated (Fig. 3A); c. Thoracic sternites with elevated processes; d. Head with frontal ridge wide and swollen together with anterofrontal ridge in one callosity (see Figs 2C, E, 3A–B); e. Antennal calli poorly separated from vertex and from each other, sometimes not separated at all (Figs 2C, E, and 3A); f. Anterolateral callosity of pronotum very long, commonly reaching midpoint of lateral margin of pronotum (Figs 1, 2); g. Vaginal palpi of female genitalia relatively short with proximal ends fused (Fig. 4E).

Overall there are no characters to separate *Ivalia*, *Amphimeloides*, and *Taizonia*. As *Ivalia* is senior to *Taizonia*, *Ivalia* remains valid and because *Amphimeloides* and *Ivalia* were published in the same paper, we here choose *Ivalia* as the name to use.

Diagnostic characters of *Ivalia.* Adult beetles small to medium sized (2–5mm), convex in lateral view. Color metallic or nonmetallic dark or light shades with spots or stripes. Antennal calli poorly to moderately developed, flat to slightly raised, anterior ends somewhat triangular, entering into interantennal space, sulci surrounding antennal calli poorly developed. Eyes small, lateral, orbit narrow, antennal sockets separated by a distance subequal to two times width of orbit or more. Frontal ridge short, wide, flat to moderately raised; anterofrontal ridge wide, flat to moderately raised. Antenna hardly reaching middle of elytron, distal antennomeres widened. Labrum deeply incised. Maxillary palp long, second and third palpomeres moderately thick, distally enlarged, last pointed. Pronotum transverse, without impressions, anterior coxal cavities open behind. Elytron with irregular punctures, posteriorly narrowed; epipleuron wide, horizontal, reaching near apex. Hind wing present or absent. Thoracic sternites with raised process in middle: prosternal intercoxal process with longitudinal vertically raised ridge along middle, process on metasternum usually circular. Metacoxa greatly enlarged, ventrally with a groove and ridge for reception of femur. Metatibia in dorsal view characteristically curved with either ends directed laterally; dorsal surface with sharp lateral margin and flat mesal margin. Tarsal claw appendiculate. Vaginal palpi joined at proximal end. Spermathecal duct not coiled.

Material examined. *Amphimeloides dorsalis* Jacoby: Holotype. Labels: 1) Type HT; 2) Ceylon, G. Lewis, 1910–320; 3) Dikoya, 3,800–4,200 ft. 6.XII–16.I.82; 4) *Amphimeloides dorsalis* Jac.; 5) Right hind leg mounted in balsam, S. Maulik, 1929; 6) HT found in dwr. parts missing G. A. Samuelson det. 1974 (BMNH).

Ivalia viridipennis Jacoby: Syntypes male and female. Labels: 1) Ceylon, G. Lewis, 1910–320; 2) Dikoya, 3,800–4,200 ft. 6.XII–16.I.82; 3) Syntype *Ivalia viridipennis* Jacoby (2 BMNH).

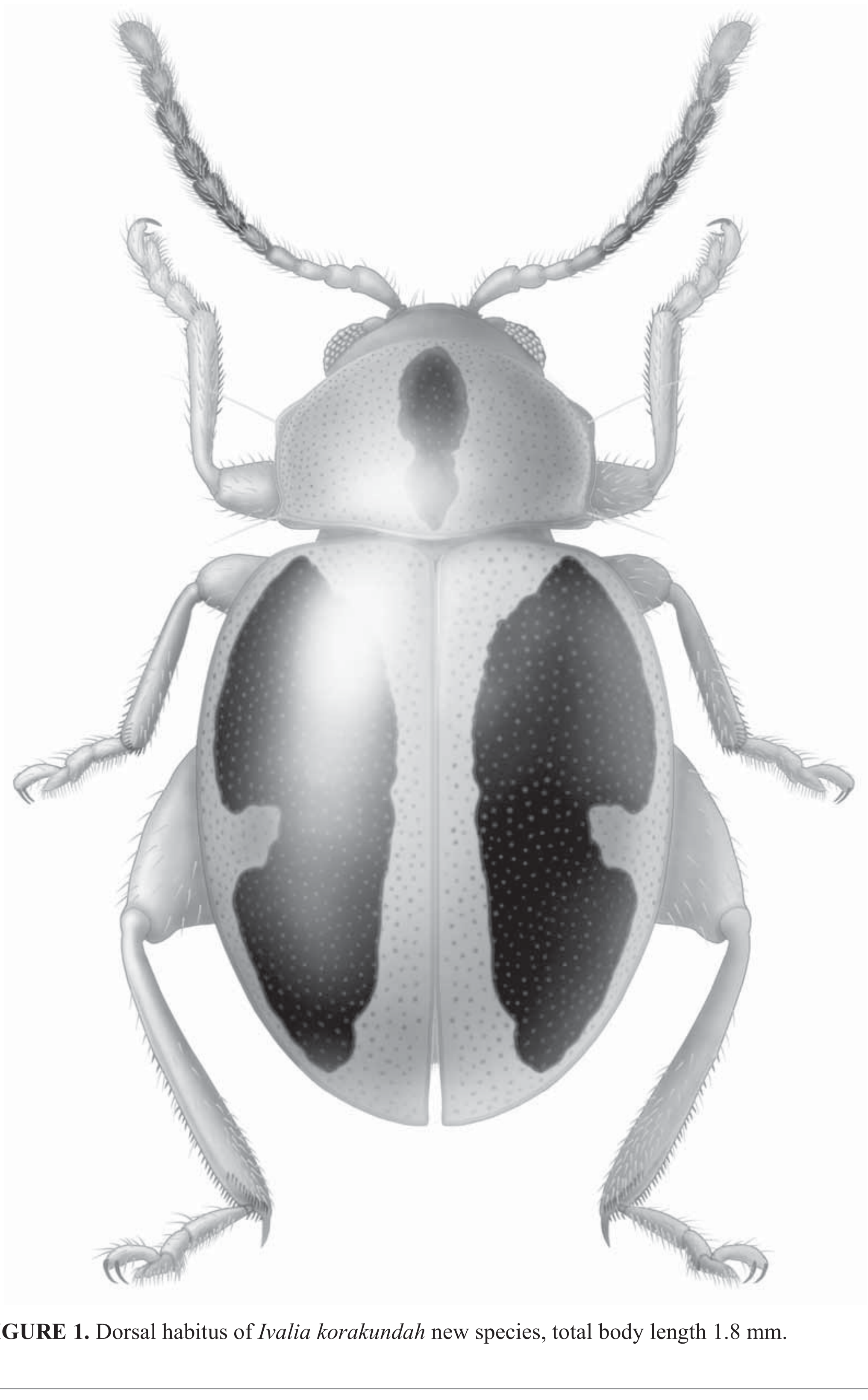

FIGURE 1. Dorsal habitus of *Ivalia korakundah* new species, total body length 1.8 mm.

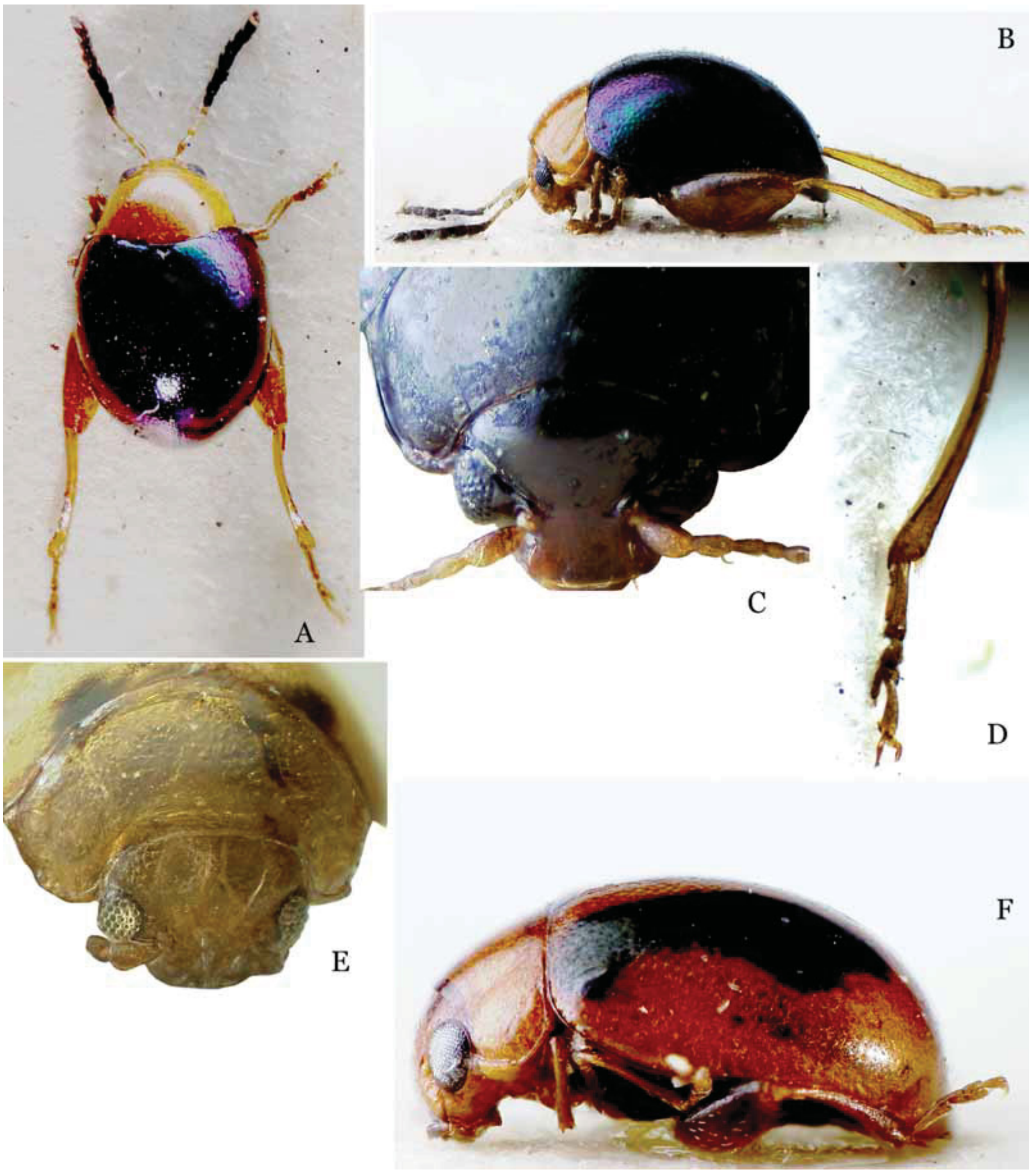

FIGURE 2. *Ivalia* species. A-D *I. viridipennis*, A, dorsal habitus, B, lateral habitus, C, anterior view of head, D, metathoracic leg; E, *I. bella*, frontal view of head; F, *I. dorsalis*, holotype, lateral habitus.

Taizonia bella Chen: Holotype male. Labels: 1) Kankau (Koshun) Formosa, H. Sauter V. 1912; 2) Holotypus; 3) *Taizonia bella* n. g. n. sp. S. H. Chen det. (DEIM).

Schereria martensi Medvedev: Holotype male. Labels: 1) 179a Kaski Dist., oberhalb, Dhumpus Berlese, 2100m, Martens & Ausobsky 8/10 Mai 80; 2) Holotypus; 3) Holotypus; 4) Schereria martensi m. L. N. Medvedev det. 1983; 5) Senckenberg Museum Frankfurt/Main (SMFM).

Ivalia korakundah **Prathapan, Konstantinov and Duckett, new species**
(Figs 1, 3–8)

Description of adult. Size moderate, length (excluding head) 1.8 to 2.0 mm, width 1.0 to 1.2 mm, oblong, narrowed between elytra and prothorax, elytra ovate. Color lemon yellow; fourth antennomere onwards piceous, last antennomere lighter than preceding one. Labrum and clypeus brownish. Eye black to crystal white, surrounded by dark brown ring that extends to gena, distinct only in specimens with lighter eyes. Pronotum with black medial longitudinal stripe hardly reaching anterior or posterior margin, narrowed at both ends, widest in anterior 1/3, margins indistinct as color gradually lightens and merges with surrounding yellow. Pronotal stripe variable in size and prominence. Each elytron with broad black stripe narrowing to either end, widest at anterior 1/3 followed by a transverse, deep emargination from middle of lateral side. In some specimens it almost divides elytral stripe into two. Lateral sides and margins of thoracic sternites tend to be dark brown, coxae light yellow. First three abdominal sternites concolorous with thoracic sternites.

Head (Figs 1, 2A–B) hypognathous. Frons and vertex form slightly convex line in lateral view. Vertex with shallow, minute, moderate sized punctures. Supraorbital pore circular, not surrounded by shallow grooves or tiny setiferous punctures, bearing an upcurved seta slightly shorter than second antennomere. Antennal callus 1.5 times wider than long, length slightly exceeding diameter of antennal socket, slightly raised, anterior end almost obtusely angulate, entering into interantennal space. Midcranial suture absent. Supracallinal sulcus shallow, poorly developed. Suprafrontal sulcus weak but distinct. Midfrontal sulcus short, deep. Supraantennal sulcus narrow, stronger than suprafrontal sulcus. Supraorbital sulcus short, shallow, ill defined. Orbital sulcus distinct. Subgenal suture narrow, distinct. Orbit narrow, subequal to transverse diameter of antennal socket. Interantennal space about twice as wide as diameter of a socket, subequal to transverse diameter of eye. Frontal ridge short, wide, slightly convex; anterofrontal ridge broad, as high as frontal ridge, laterally as high as medially, anteriorly flat above clypeus with concave anterior margin (Fig. 3A). Frontal ridge and anterofrontal ridge together appear as flattened equilateral triangle, merging above clypeus. Lateral margin of frons with two closely placed rows of setae merging below antennal socket: mesal row with long and lateral row with short setae. Frontoclypeal suture with a row of long setae. Labrum (Figs 3A–B) with six setiferous pores arranged in a curved, transverse row; distance between middle four pores less than that between lateral pore and adjacent one. Margin of incision on labrum with short setae.

Maxillary palp (Fig. 3B) exceeds basal two antennomeres in length; basal palpomere tiny, not longer than wide; second club-shaped, subequal to, or slightly longer than third; third club- shaped, thicker than second, widening towards apex; fourth thin, a little longer than half of third.

Antennae hardly reach middle of elytron. First antennomere club-shaped; second thicker than third, slightly thinner than first, slightly longer than half of first; fourth

slightly longer than second but shorter than third; fifth onwards antennomeres thickened; fifth subequal to third in length; fourth and sixth subequal in length; seventh slightly longer, much thicker than sixth; seventh subequal to eighth; ninth and tenth separately slightly shorter than eighth; tenth 1.4 times longer than wide; eleventh shorter than two times length of tenth.

Pronotum 1.4 times wider than long, anteriorly wider than posteriorly, convex. Lateral margin weakly curved, anteriorly wider than posteriorly. Anterolateral callosity well developed, convex, as long as 1/3 of lateral margin including anterolateral callosity, anteriorly higher than posteriorly, seta-bearing pore situated on dorsal posterior face of callosity forming indistinct denticle at pore, diameter of pore exceeding width of lateral margin; posterior callosity protruding, about 1/3 as long as anterolateral callosity; seta on anterolateral callosity as long as lateral margin; seta on posterolateral callosity slightly longer than half of seta on anterolateral callosity. Anterior margin straight, posterior margin gently curved; disc with small punctures with extremely minute seta arising from each puncture visible at high magnification; minute as well as medium sized scattered punctures also present.

Intercoxal prosternal process (Fig. 3B) narrow in middle, apically widened with rounded apex, projecting much beyond coxa. Length of intercoxal prosternal process from anterior margin of sternite to posterior end 3.6 times distance between anterior margin of prosternum to coxal cavity; width of intercoxal prosternal process at middle less than distance between anterior margin of prosternum to coxal cavity. Width of mesosternal intercoxal process subequal to half of distance between anterior margin of mesosternum to posterior end of intercoxal process (cf. Fig. 3C). Distance between anterior margin of mesosternum to mesocoxal cavity slightly less than width of mesosternal intercoxal process. Prosternum slightly longer than metasternum; mesosternum shorter than metasternum. Intercoxal prosternal process with a vertically elevated ridge along middle, ridge being indistinct in proximal half, pronounced beyond middle with longitudinal depressions on either side of ridge. Mesosternum with indications of a horse-shoe shaped raised process on top, but poorly developed in most specimens (Fig. 5A). Metasternum with a circular depression with well-defined, ring-like ridge surrounding it (Fig. 5A).

Elytron without humeral callus, with maximum width at proximal 1/3, tapering to apex (Figs 1, 3D). Elytral apex apparently concave, forming acute angle with sutural margin. Lateral margin of elytron delimiting epipleuron dorsolaterally, reaches up to sutural margin; visible from above except in distal 1/4. Elytral punctures stronger than those on pronotum; interstices flat with small minute punctures, distance between punctures up to diameter of three punctures in middle of disc. Elytral punctures with minute seta visible under high power. Internal surface (Fig. 3D) uniformly invested with small granulations. Elytral binding patches absent. Mesoscutellum triangular, broader than long, impunctate. Pro- and mesotibiae without apical spine. Width of pro- and mesofemora subequal to maximum width of epipleuron. Profemur slightly shorter than protibia, ventral

side nearly flat, dorsally convex. Foretibia rounded in cross section, slender, proximally half as thick as distally. First protarsomere in male not distinctly wider than in female, ventrally flat, with short, pointed setae, long setae absent. Second protarsomere narrower than first; third longer than second, shorter than first, deeply bilobed; fourth slightly shorter than two times length of third, ventral side of third tarsomere with long capitate setae. Mesofemur slightly longer than mesotibia. Metafemur about two times longer than wide (Figs 1, 3C), posteriorly with a dorsal groove and a ventral ridge for reception of tibia. Metatibia slightly longer than metafemur. Metatibia curved in lateral view. Dorsal surface convex with flat apex; mesal margin of dorsal surface with a short row of sharp bristles at distal end; lateral margin with sharp, long spinules from distal end to middle or slightly beyond. Metatibia about 3.4 – 3.7 times longer than first metatarsomere. Metatibial spur 1.3 times longer than tarsal claw (Figs 3E–F). Third metatarsomere bearing specialized spatulate setae ventrally (Figs 3F–G). Claw long, narrow with a short appendix (Fig. 3F). Intercoxal process of first abdominal ventrite with oval depression in middle, bearing ridge on either side those join together anteriorly with acute process between metacoxae. Abdomen with five visible ventrites. Length of first abdominal ventrite along middle slightly more than length of next three ventrites combined; fifth ventrite longer than fourth but shorter than fourth and third combined (Fig. 4D). Last visible abdominal tergite of female nearly as wide as long, with a shallow groove along middle (Fig. 4C).

Female genitalia with receptacle of spermatheca (Fig. 4A) cylindrical, about four times longer than wide, widest in middle, slightly narrowed towards either end; pump curved, vertical part very short, horizontal part about half as long as receptacle, without denticle at apex; duct originate away from receptacle, curved towards receptacle, hardly reaching middle of receptacle. Vaginal palpi (Fig. 4E) lightly sclerotized, proximally fused like a horse shoe, narrowed from proximal end to distal end, lateral and mesal margins hardly form acute angle, setae not longer than maximum width of a palpus, placed near apex and lateral margin; tignum (Fig. 4B) curved with a central canal, distal sclerotization broad, spoon shaped, without setae, proximal sclerotization laterally flattened, broad, but narrower than distal sclerotization.

Aedeagus (Figs 5B–C) in ventral view proximally wider than distally, highly convex along ventral side with flat, raised, rounded apex; in lateral view, moderately curved, widest near middle with acute, strongly recurved apex. Tegmen Y-shaped.

Remarks. This species can be distinguished from the two described species of south Indian *Ivalia* by the following characteristics, including coloration and tibial spinules. *Ivalia obrieni* (Gruev and Askevold) has a transverse dark basal band on the pronotum (*I. korakundah* has a black medial longitudinal stripe on pronotum) and black elytron with lateral yellow band (*I. korakundah* has a black band along middle of elytron, the band being transversely emarginated in middle). *Ivalia indica* (Gruev and Askevold) is entirely yellow brown without black stripes. Head of *I. indica* has four deep punctures arranged in a transverse row near posterior margin of antennal calli. Such punctures are absent in the

other two species. Elytral punctures are also much stronger in *I. indica* than in other south Indian species. On the lateral edge of the dorsal surface of the metatibia, *I. obrieni* has 3–4 spines while *I. korakundah* has a row of more than ten spinules.

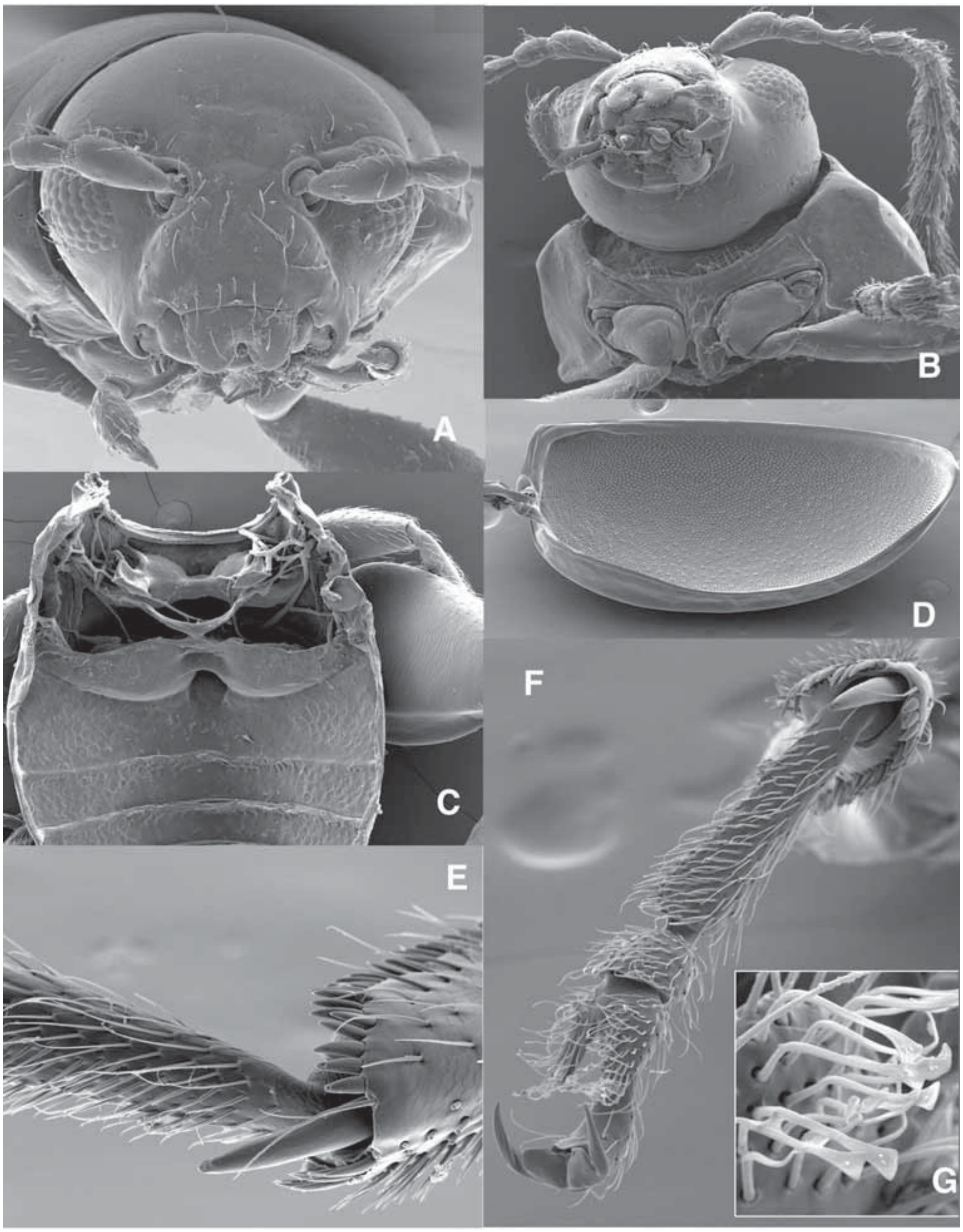

FIGURE 3. *Ivalia korakundah*, adult. A, frontal view of head; B, ventral view of head and pronotum; C- G, Qiagen™ cleared material; C, dorsal view of pterothorax and abdomen, note tracheoles and metendosternite; D, interior view of elytron showing regular granulations; E, metatibial spur; F, ventral view of metatarsi; G, tarsal setae of third tarsomere, total width of image 25 microns.

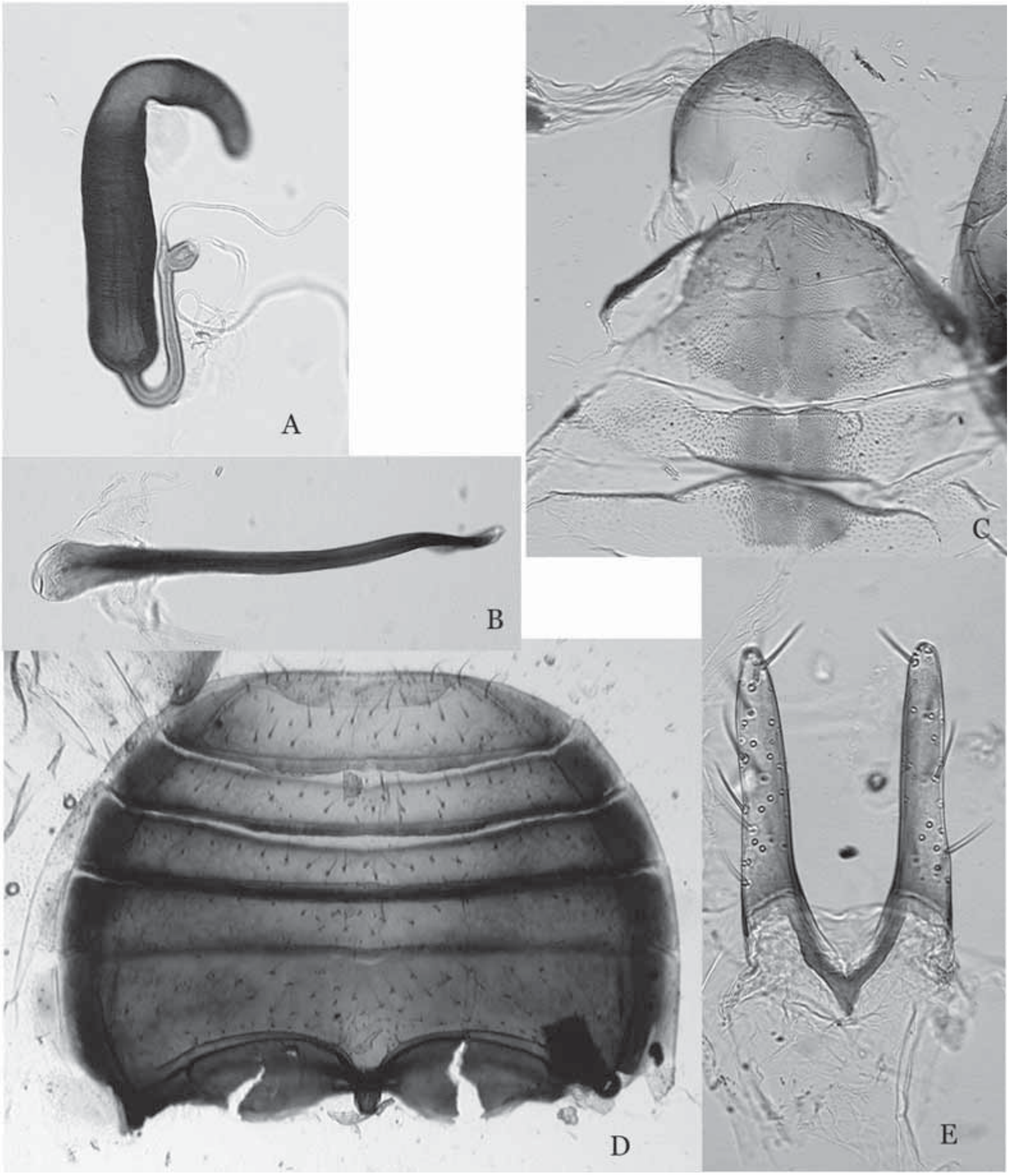

FIGURE 4. *Ivalia korakundah,* female. A, spermatheca; B, tignum (eighth sternite); C, apical abdominal tergites; D, ventral view of abdomen; E, vaginal palpi.

Adults and larvae of *Ivalia korakundah* were collected at Korakundah Estate in south India, by sifting moss from the trunk of large pine trees. At Doddabetta Valley, adults were collected by sifting the moss *Isopterygium* sp. (Hypnaceae) growing on rock. Females of a closely related alate yellow species that is widely distributed throughout south India (called here *Ivalia* sp. 1) in which the thoracic maculation is absent and the elytral stripe is not transversely emarginate were also collected at Korakundah Estate. The elytral stripe is

reduced to a circular spot or absent in specimens from Kerala and Karnataka. The scutellum in *I. korakundah* is triangular, much wider than long, and brown in color while in the other species it is rounded and black. The alate *Ivalia* sp. 1 has a well developed humeral callus and a longer metathoracic sternite. Structure of its female genitalia is also different. Receptacle of the spermatheca is much broader in the alate *Ivalia* sp. 1 compared to that of *I. korakundah*.

Type material. Holotype ♂. Labels: 1) South India Western Ghats Tamil Nadu, Nilgiri, env. Ooti, Korakundah Tea estate 25.XI.2003 2300m, N11.14'44"E76.33'31", leg. Konstantinov, Prathapan, Saluk; 2) Holotype *Ivalia korakundah sp. nov*. des. Prathapan, Konstantinov, Duckett (USNM). Paratypes 30 specimens: the same labels as holotype (25 USNM, 3 PKDC, 2 BMNH). Two specimens: South India Western Ghats Tamil Nadu, Doddabetta, 22.VI.2004 2600m, N11°23'59"E76°44'06" Prathapan K. D. Coll. (PKDC). Four specimens: South India Western Ghats Tamil Nadu, Doddabetta Valley, 24.VI.2004 Prathapan K. D. Coll. (PKDC).

Etymology. The specific epithet refers to the Korakundah Tea Estate of the Nilgiris where the holotype was collected; it is a noun in apposition.

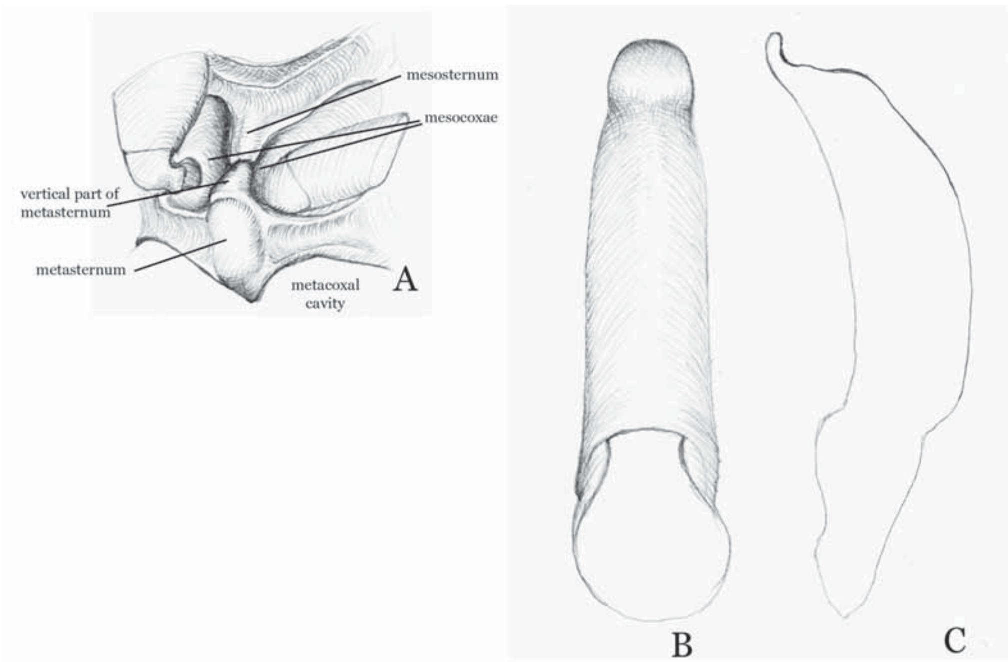

FIGURE 5. *Ivalia korakundah.* A, ventral view of meso- and metathorax; B, ventral view of aedeagus; C, lateral view of aedeagus.

Description of larva

Third and second instars (Figs 6, 7, 8C–D). Habitus: eruciform, white with melanized sclerotized tubercles (in alcohol). Mature larva length 1.80–3.09 mm, n=4.

Head (Figs 6, 7C) rounded, lightly sclerotized and melanized; frontal arms V-shaped

bowing outwards posterior to antennal sockets (Fig. 7C); epicranial stem short; endocarina robust under light microscopy, extending from base of frontal arms to clypeus. Frons bearing 3 pairs of long setae; vertex highly convex, each epicranial half bearing 7 long setae (5 dorsal, 2 ventrolateral) and 3 small conical sensilla (Figs 7D–E) high on vertex. Stemmata absent. Antenna (Fig. 7B) reduced in size, retractile, appearing 3-segmented; antennal socket pronounced, located anterior to ends of frontal arms; basal segment partially membranous, segment 2 partially membranous with apical membranous area bearing third segment; third segment formed by a large conical, fragile sensory papilla and a lightly sclerotized oval sensory patch and a short basiconic sensillum laterad and two long basiconic sensilla mesad borne in a membranous area; sclerotized patch bearing one seta, 3 long and one short basiconic sensilla. Clypeus (Fig. 7C) transverse, edges rounded laterally, bearing 3 pairs setae. Labrum (Figs 7A, C) transverse, with pronounced medial emargination, sclerotized, lateral edges rounded; dorsal surface bearing 2 pairs of long setae and pair of sensory pores near midline; anterior margin bearing 5 pairs of short setae medially. Epipharynx with central apical patch of microtrichia, paired patches of campaniform sensilla laterad of this patch. Mandibles symmetrical, palmate, 4-toothed, largest tooth bearing small serration; external face bearing 2 prominent setae and 2 minute depressed sensilla (Fig. 7A); penicillus formed by a single row of 5–6 thickened setae. Prementum lightly sclerotized, bearing 3 pairs of setae (Fig. 7A), 1 ventromedial long seta at each ventrolateral corner, 1 pair short setae just posterior to mentum and 1 pair of long setae equidistant between those pairs; postmentum membranous, bearing 2 well developed and 1 minute setae and 1 sensory pore on each side. Maxilla (Fig. 7A) with cardo transverse, sclerotized, bearing 1 short seta laterally; stipes elongate bearing 2 lateral setae, palpiger bearing 2 setae ventrally; mala with sclerotized apex with 6 setae around 2 stout pedunculate seta (appearing 2-segmented), dorsally bearing many long setae without visible setal sockets; maxillary palp 3 segmented, first segment bearing 1 short ventro-lateral seta, second segment bearing 1 short dorsal seta, distal segment bearing 1 short medial seta, 1 lateral depressed sensillum, ventral to 1 long placoid sensillum borne in groove, apex bearing 5 basiconic sensilla of varying sizes (Fig. 7G). Labium (Figs 7A, G, H) with labial palpi 2-segmented, basal segment with small ventrolateral seta, distal segment with 1 ventrolateral depressed sensillum, and 1 lateral elongate placoid sensillum, apex bearing 9 sensilla, appearing basiconic, varying in size as shown and roughly arranged in a ring (Figs 7G–H). Hypopharynx lightly invested with microtrichia on interior surface (Fig. 7H), this area bordered by a row of 4 stout conical setae; apically bearing 4 depressed sensilla, and 2 stout conical setae arranged in two rows, depressed sensilla arranged 1 at base of each palp (Fig. 7F) and directly interior to each short seta (Fig. 7H). Gula absent.

Thorax. Prothorax narrower than other thoracic segments (Fig. 6B); pronotum lightly sclerotized and entirely melanized (Fig. 6A) bearing 2 transverse rows of long setae (10 anterior, 6 posterior); pro-pleuron bearing 3 unisetose tubercles, pre-hypopleural and post-hypopleural being lightly sclerotized and melanized, posterior epipleural being more

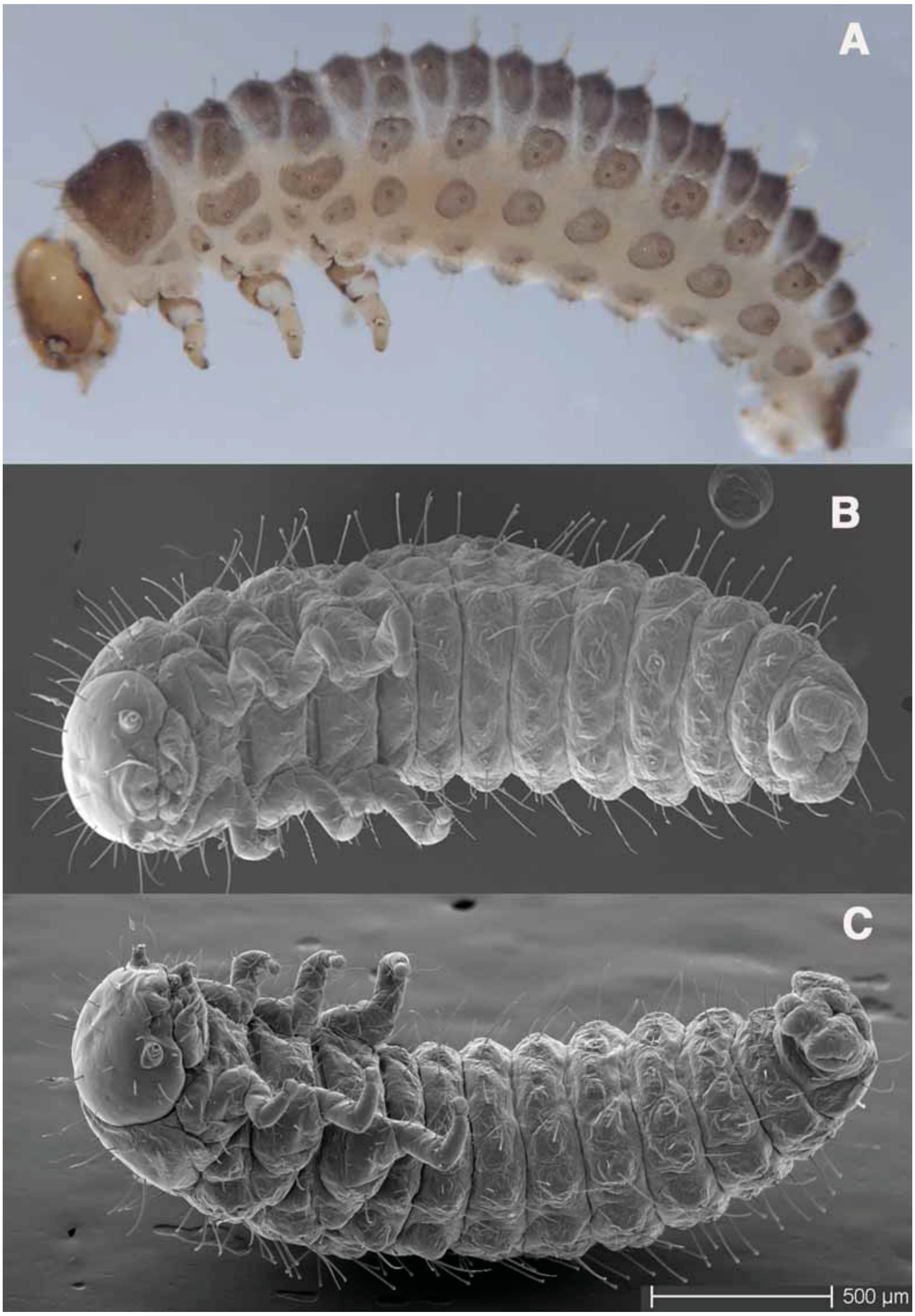

FIGURE 6. *Ivalia korakundah,* 3rd instar larva. A, left lateral habitus light microscopy, note melanized tubercles; B, ventral habitus, SEM coated material; C, right lateral habitus, coated material, note lack of cuticular variation between sclerotized and unsclerotized integument.

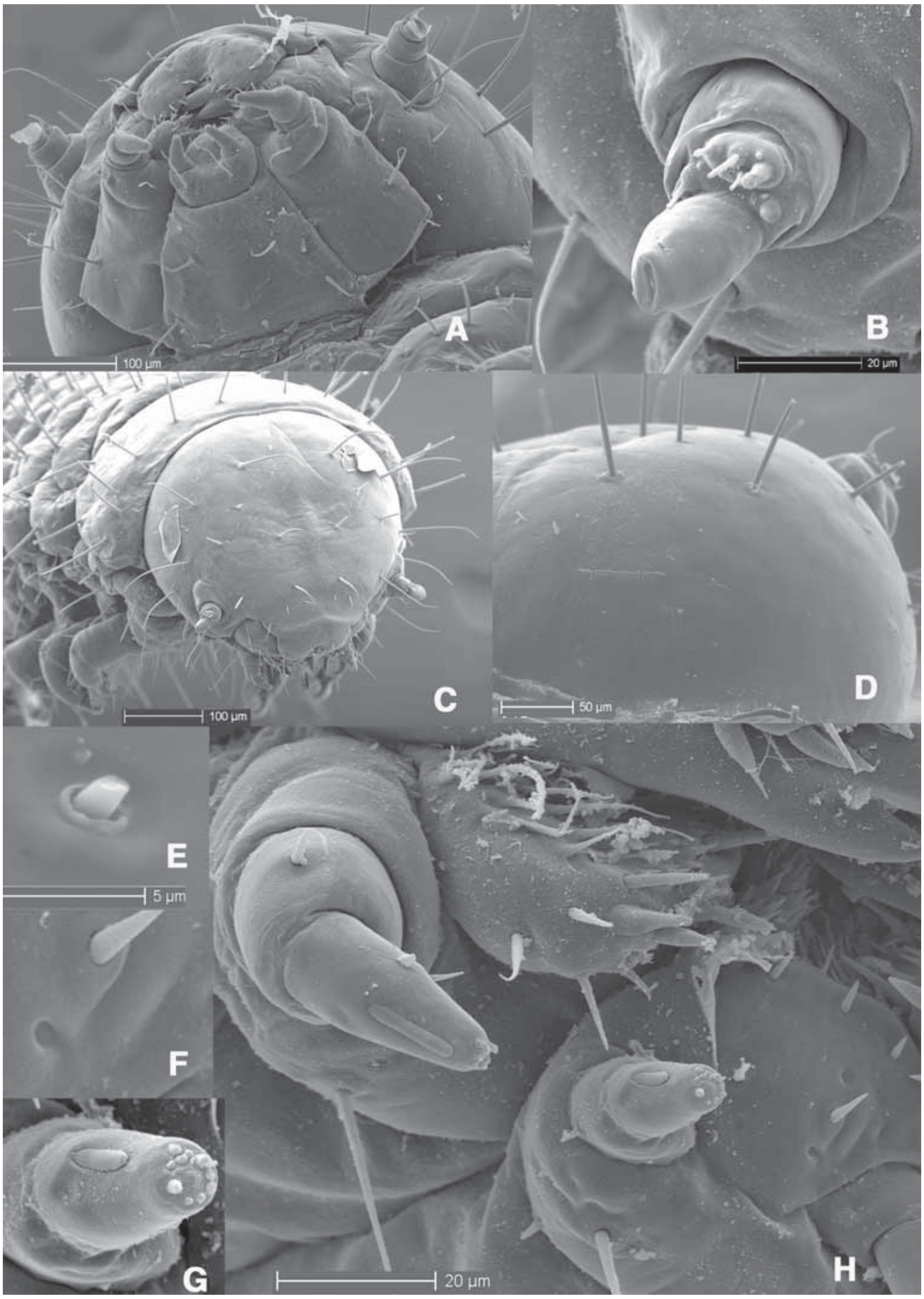

FIGURE 7. *Ivalia korakundah,* larva. A, ventral view of head capsule, (antennae damaged from critical point drying); B, antenna with intact antennal papilla; C, anterior view of head; D, dorsal view of vertex showing minute peg-like sensilla; E, detail of sensillum of the vertex; F, detail of depressed sensillum of the labium; G, apical segment of labial palp, note long basiconic sensillum and depressed sensillum on exterior lateral face; H, right maxillary palp and labium, ventral view.

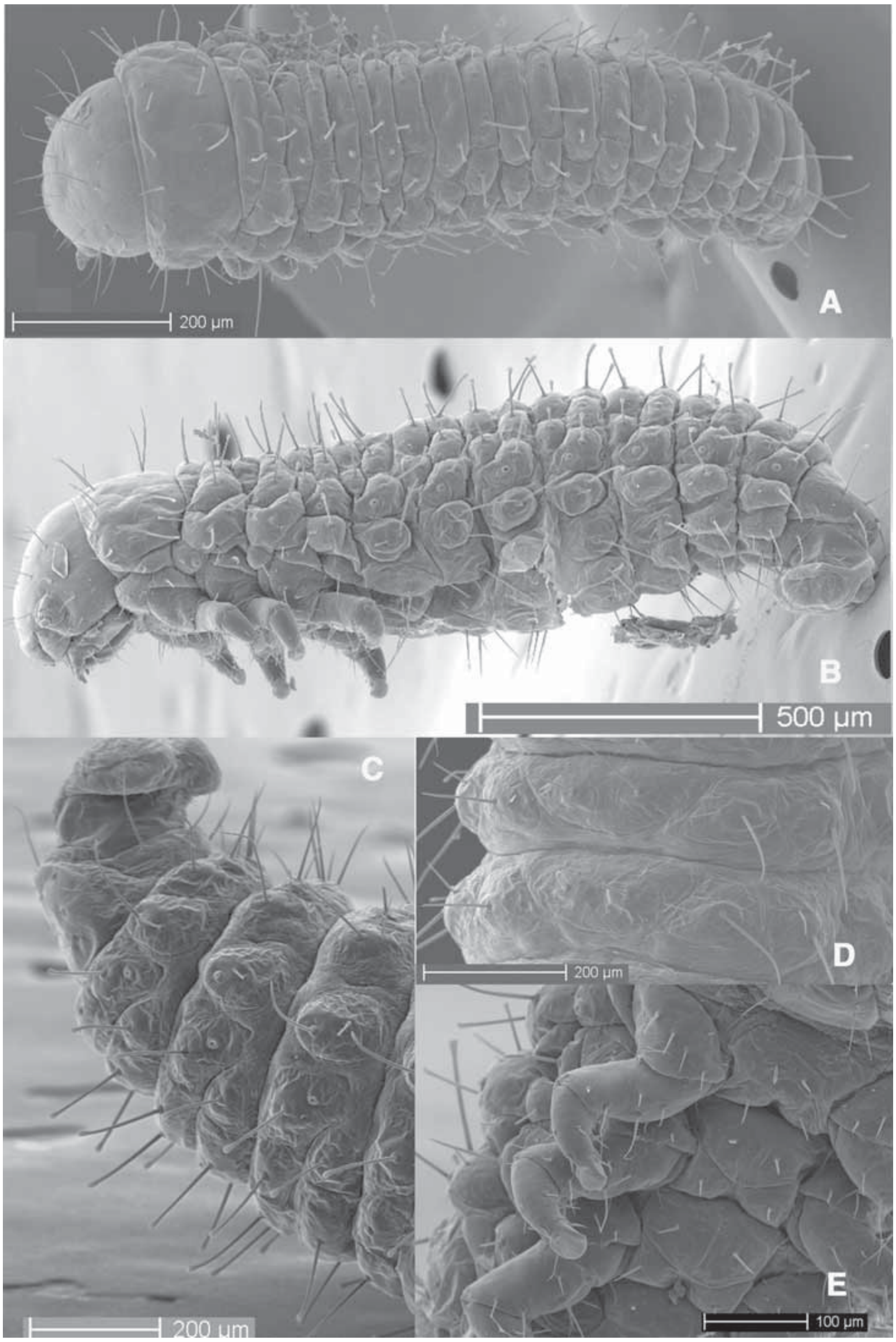

FIGURE 8. Larvae of *Ivalia korakundah.* A, dorsal view of first instar larva; B, lateral view of first instar larva (area between abdominal segments 4 and 5 damaged from critical point drying); C, lateral view of abdominal apex of third instar larva; D, ventral view of abdominal segments 2 and 3 of third instar larva; E, ventral view of first instar larva showing prothoracic and mesothoracic legs, note pillow-like pulvillus.

melanized; trochantin triangular, asetose (Fig. 6A); prosternum (Figs 6B, C) with 2 pairs of medial setae borne on sclerotized, lightly melanized tubercules. Meso- and metathorax subequal, wider than prothorax; both nota with sclerotized, melanized tubercles forming 2 plicae, anterior plica bearing 2 setae corresponding to prescutum, posterior plica corresponding to interior, exterior scutoscutellum bearing 4 setae (Fig. 6A). Meso- and metapleura each bearing 3 tubercles; anterior epiplueral tubercle bears 1 seta and in the mesothorax an annuliform spiracle; alar tubercle bearing 3 setae, posterior epipleural bearing 2 setae; meso- and metasterna with 2 pairs setae arranged equidistantly from legs and midline. Legs (Fig. 6) increasing very slightly in size from pro- to mesothorax, 5 segmented; coxa largely trapezoidal bearing 10 setae (5 short, 5 longer), trochanter with 4 long setae; femur with 5 setae; tibia with 7 setae; tarsungulus slightly curved bearing 1 long seta on inner margin (Fig. 6C); pulvillus very large, fleshy, regularly grooved, fan-like, fixed posterior to tarsungulus.

Abdomen. All dorsal abdominal setae capitate, all ventral filiform except where noted**.** Abdominal segments I–VIII dorsally with sclerotized melanized tubercles forming 2 plicae, anterior plica formed from interior prescutal tubercle and bearing 2 long setae, exterior prescutal tubercles each bearing 1 seta, posterior plica formed by interior scutoscutellar tubercle (2 setae), exterior scutoscutellar tubercle (1 setae) and posterior parascutal tubercle bearing 1 seta and spiracle; ventrally with 1 transverse eusternellar bisetose tubercle, interior sternellar and exterior sternellar tubercles each bearing 2 setae, medial seta shorter on each tubercle (Fig. 6B), epiplural tubercle bearing 2 setae, anterior short (Figs 6C, 8C). Spiracles 1–8 annuliform, located on the pleural tubercles near setal base. Segment IX (pygidum of LeSage & Zmudzinska-Krzesinska 2004) with flattened melanized sclerotized area, dorsally covering anal pseudopod, bearing 4 pairs setae, arranged apically and laterally, ventral side with 2 pairs setae, mesal pair shorter, lateral pair long. Segment X forming anal pseudopod, anal disc bearing multiple campaniform sensilla, encircled by a ring of 8 very short slender setae.

First Instar (Figs 8 A, B, E) Length mean = 1.08 mm, n=2. The first instar is similar to the second and third instars; however, neither of the two individuals were dissected so we cannot quantify differences. Notably, no structures for use as egg bursters were detected.

Discussion and molecular results

Adults and larvae were judged conspecific because of sequencing results and comparison to other flea beetle species including *Ivalia* sp. 1 from India collected approximately 300 km away, in Ponmudi, Kerala. The COI sequences obtained for adults and larvae from Korakundah were identical in amino acid sequence, and very similar in base pairs. This discrepancy was mostly due to variations in different 3rd position sites. Only 19 out of 540 reliably sequenced bases showed variation among taxa. Two of these sites had unique

bases, one in a larva and one in an adult. These sequences varied among individuals; 0.5% pairwise distance between the sequences from the two larvae, 0.9% – 2.2 % between sequences pairings between an adult and a larva (the adult shown in Figure 3 is the least closely related to the other three individuals). The sequences from the two adults had a pairwise distance of 2.1%.

These sequences were compared to sequences from specimen of *Ivalia* sp. 1. This specimen had 15 amino acid differences in the 540 reliably sequenced nucleotides and had between 18.7 and 17.4 % pairwise base differences with the other 4 specimens sequence. We failed to obtain amplifiable DNA from the *Ivalia* sp. 1 specimens collected with *I. korakundah*. However, because of the large number of amino acid differences in the *Ivalia* sp. 1, and the fact that the genetic variation among the larvae and the adults was equivalent to the variation between adults, we are secure that the larva described is *I. korakundah*. The larvae of *Ivalia korakundah* are typical of flea beetles in many ways; however, some novelties were observed. We compared *I. korakundah* larvae with published accounts of *Altica chalybea* Illiger and *A. woodsi* Isley (LeSage & Zmudzinska-Krzesinska 2004), *Alagoasa januaria* Bechyné (Duckett & Swigonova 2002), *Walterianella bucki* Bechyné (Duckett & Casari 2002), and *Pseudolampsis guttata* Leconte and *P. darwini* (Scherer) (Casari & Duckett 1997). These species were chosen because published work included detailed descriptions of the sensilla of the mouthparts. We also make casual comparisons with other flea beetle larvae such as those of *Ptocadica* spp. and *Pedilia sirena* Duckett based on unpublished observations (CND).

Similarities include: eruciform habitus, sclerotized melanized body tubercles, annuliform spiracles, labrum with 4 setae and 1 pair of sensilla, presence of a placoid sensillum on the dorso-lateral surface of the palpi, sensillar distribution and type on the prementum. The most notable difference between these species and *I. korakundah* is the presence of multiple basiconic sensilla on the apex of both maxillary and labial palpomeres.

Ivalia korakundah larvae appear more similar to *Altica* or *Pseudolampsis* larvae than they do to the Oedionychine larvae of *Alagoasa* or *Walterianella* owing to the strong melanization of the tubercles, the absence of highly elongate tubercles, and the presence of specialized granular integument between the tubercles. Larvae of *Pedilia sirena* and *Ptocadica* spp. (see Duckett & Moyá 1999) are also gently tuberculate, but the body tubercles are unsclerotized and asetose, and the integument is granular. Larvae of *Pseudolampsis* spp. differ from *I. korakundah* in the absence of a seta on the cardo and in the presence of stemmata; however, the enlarged pulvillus of *Pseudolampsis* is qualitatively more similar to *I. korakundah*. This similarity may be functional; *Pseudolampsis* spp. feed on aquatic plants, which might have high physical moisture like the moss *I. korakundah* feeds upon. None of the previously mentioned species except *Alagoasa januaria* has a visibly sclerotized trochantin like *I. korakundah*.

Altica chalybea and *A. woodsi* are also species that have been studied using electron

microscopy (LeSage & Zmudzinska-Krzesinska 2004). Therefore these species may be the most comparable with *I. korakundah.* Electron microscopy allows for a more accurate interpretation of certain sensilla of *I. korakundah,* some of which might have been characterized previously simply as sensory pores or campaniform sensilla. Sensilla that we might have coded as sensory pores with light microscopy include the sensilla of the vertex (Fig. 7E), which are clearly minute basiconic sensilla, the sensilla of the labial and maxillary palpomeres ventral to the long placoid sensilla (see Figs 7G–H), and the sensilla of the prementum (Figs 7F, H); these are depressed sensilla in *I. korakundah,* not campaniform sensilla as by LeSage and Zmudzinska-Krzesinska (2004) or Duckett and collaborators (Casari & Duckett 1997, Duckett & Casari 2002, Duckett & Swigonova 2002). We differ from LeSage and Zmudzinska-Krzesinska (2004) in our nomenclature for the elongate sensillum borne in a groove on the labial and maxillary palpomeres; they use the term 'elongate basiconic sensillum'. However, it is visibly the same structure they report. This structure was first reported on the labial palp by Duckett and Swigonova (2002) but not illustrated. The SEM images of larval sensilla provided here and in LeSage and Zmudzinska-Krzesinska (2004) clearly show that the SEM is a powerful tool for the study of larvae and its use is recommended so that more characters can be discovered.

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Literature cited

Casari, S.A. & Duckett, C.N. (1997) A description of immature stages of two species of *Pseudolampsis* (Coleoptera: Chrysomelidae) and a new combination in the genus. *Journal of the New York Entomological Society*, 105, 50–64.

Chen, S. H. (1934) Coléoptères Halticinae recuellis par M. H. Sauter a Formose. *Annales de la Société Entomologique de France*, 53, 175–185.

Duckett, C.N. & Casari, S. (2002) First descriptions of larval stages of *Walterianella bucki* Bechyné (Coleoptera: Chrysomelidae: Alticini) and notes on life history. *Coleopterists Bulletin*, 56, 170–181.

Duckett, C.N. & Moyá, S. (1999) A new species of *Ptocadica* Harold (Chrysomelidae: Alticini) from Costa Rica. *Coleopterists Bulletin*, 53, 311–319.

Duckett, C.N. & Swigonová, Z. (2002) Description of the immature stages of *Alagoasa januaria* Bechyné (Chrysomelidae: Alticini). *Journal of the New York Entomological Society*, 110, 115–126.

Gruev, B. & Askevold, I.S. (1988) New species of Alticinae (Coleoptera: Chrysomelidae) from South India in the genera *Taizonia* and *Longitarsus. Pan-Pacific Entomologist,* 64, 139–145.

Jacoby, M. (1887) Descriptions of the Phytophagous Coleoptera of Ceylon, obtained by Mr. George Lewis during the years 1881–1882. *Proceedings of the Scientific Meetings of the Zoological Society of London*, 5, 65–118.

Konstantinov, A.S. (1998) Revision of the Palearctic species of *Aphthona* Chevrolat and cladistic classification of the Aphthonini (Coleoptera: Chrysomelidae: Alticinae). *Memoirs on Entomology, International.* Associated Publishers, Gainesville, 429 pp.

Konstantinov, A.S. & Duckett, C.N. (2005) A description of four new species of *Clavicornaltica* Scherer from Continental Asia. *Zootaxa*, 1037, 49–64.

LeSage, L. & Zmudzinska-Krzesinska, A. (2004) Immature stages of the grape flea beetles *Altica chalybea* Illiger and *A. woodsi* Isley (Coleoptera: Chrysomelidae). *In*: Jolivet, P., Santiago-Blay, J. & Schmitt, M. (Eds.), *New Developments in the Biology of Chrysomelidae*. SPB Academic Publishers, The Hague, The Netherlands, pp. 503–528.

Maddison, D.R. & Maddison, W.P. (2001) MacClade version 4.03. Sinauer Associates Publishers, Inc. Sunderland, Massachusetts, CD ROM.

Maulik, S. (1926) Coleoptera. Chrysomelidae (Chrysomelinae and Halticinae). *In*: Shipley, A.E. (Ed.), *The fauna of British India including Ceylon and Burma*. Taylor and Francis, London, 422 pp.

Medvedev, L.N. (1984) Chrysomelidae from the Nepal Himalayas. 1. Alticinae (Insecta: Coleoptera). *Senckenbergiana Biologia*, 65, 47–63.

Medvedev, L.N. (2001) Chrysomelidae of southern Asia (Coleoptera). *Entomologica Basiliensia*, 23, 159–191.

Motschulsky, V. (1866) Essai d'un Catalogue des Insectes de l'ile de Ceylan. *Supplement. Bulletin de la Société Impériale des Naturalistes de Moscow,* 39, 393–446.

Ogloblin, D.A. (1930) De quelques especes de Halticinae (Col. Chrysomelidae) de la collection de V. Motschulsky. *Museo Nacional de Sciences Naturales Madrid*, 10, 84–111.

Scherer, G. (1969) Die Alticinae des indischen Subkontinentes (Coleoptera - Chrysomelidae). *Pacific Insects Monograph*, 22, 251 pp.

Simon, C., Frati, F., Beckenback, A., Crespi, B., Liu, H. & Flook, P. (1994) Evolution, weighting, and phylogenetic utility of mitochondrial gene sequences and a compilation of conserved PCR primers. *Annals of the Entomological Society of America*, 87, 51–701.

Thompson, J.D., Higgins D.G. & Gibson, T.J. (1994) CLUSTAL W: improving the sensitivity of progressive multiple sequence alignment through sequence weighting, position-specific gap penalties and weight matrix choice. *Nucleic Acids Research,* 22, 4673–4680.